

HEROLD (J)

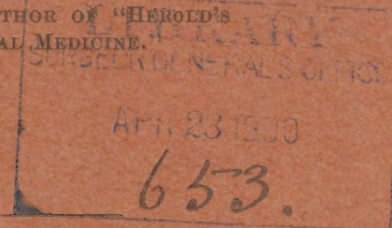
SIGNS AND TESTS OF DEATH.

BY

JUSTIN HEROLD, A. M., M. D.

NEW YORK.

FORMERLY CORONER'S PHYSICIAN OF THE CITY AND COUNTY OF NEW YORK; LATE HOUSE PHYSICIAN AND SURGEON OF SAINT VINCENT'S HOSPITAL, NEW YORK CITY; MEMBER OF THE NEW YORK COUNTY MEDICAL ASSOCIATION, NEW YORK COUNTY MEDICAL SOCIETY, NEW YORK MEDICO-LEGAL SOCIETY, NEW YORK SOCIETY OF MEDICAL JURISPRUDENCE, NEW YORK ACADEMY OF MEDICINE, GERMAN MEDICAL SOCIETY OF THE CITY OF NEW YORK; AUTHOR OF "HEROLD'S LEGAL MEDICINE."



NEW ORLEANS
MEDICAL AND SURGICAL JOURNAL.
1899.

1895-9, 61, 549; 610, 669.

SIGNS AND TESTS OF DEATH.

BY JUSTIN HEROLD, A. M., M. D., NEW YORK.

Formerly Coroner's Physician of the City and County of New York; Late House Physician and Surgeon of Saint Vincent's Hospital, New York City; Member of the New York County Medical Association, New York County Medical Society, New York Medico-Legal Society, New York Society of Medical Jurisprudence, New York Academy of Medicine, German Medical Society of the City of New York; Author of "Herold's Legal Medicine."

*"How wonderful is Death—
Death, and his brother Sleep!"*—SHELLEY, *Queen Mab*, I.

"To be buried alive is, beyond question, the most terrific of these extremes which has ever fallen to the lot of mere mortality. That it has frequently, very frequently, so fallen, will scarcely be denied by those who think. The boundaries which divide Life from Death are at best shadowy and vague. Who shall say where the one ends, and where the other begins? We know that there are diseases in which occur total cessations of all the apparent functions of vitality, and yet in which these cessations are merely suspensions, properly so called. They are only temporary pauses in the incomprehensible mechanism. A certain period elapses, and some unseen mysterious principle again sets in motion the magic pinions and the wizard wheels. The silver cord was not forever loosed, nor the golden bowl irreparably broken. But where, meanwhile, was the soul!"* Real death never misses fire, although the steed upon which this grim messenger travels this globe is pictured as a swift and pale horse, still he has a sure aim.

Death is the cessation of all the phenomena of the human body which we call vital; the cessation of all acts, whether in animal or plant life. It means to be deprived of life, to be opposed to life and to living; it means to be reduced to that state of a being in which the organs of motion and of life are

* POE, *The Raven*.

LIBRARY
SURGEON GENERAL'S OFFICE

APR 23 1900

653.

irrevocably lost to a possibility of their resuscitation; their capabilities and functions are lost. The definite cessation of all acts constitutes death; the ensemble of these acts in an organized being constitutes life. Where there is a total and permanent cessation of all animal and vegetable functions, vital in their importance, that cessation certainly and surely means death. The organs not only cease to act, but also lose the susceptibility of renewed action, by whatever means that may be employed. This cessation of function is the end of all physiologic action, yet really the beginning of another life (what becomes of the mind or thinking principle, in man or animal, after death, is a matter of philosophic conjecture or religious faith, and can not be treated of here), a life characterized by tissue changes and appearances at different stages. It is a second life of metamorphoses and an existence of parasites, entirely different from the first life, but from a scientific standpoint equally as interesting. Death is not an inevitable transition to every living creature; the protoplasm of which we are constituted passes into the state of dead and putrid matter in a very interesting manner—in a manner as deep and difficult of solution as the necessarily insoluble WHY.

Unicellular organisms divide, and from this mere division of self take unto themselves a distinct immortality of their own, the individual elements dying; propagation is then confined to certain elements, the unicellular immortality is lost as soon as the elements have advanced in differentiation.

The term of existence that nature has fixed for man is seldom reached, death by violence or disease is the rule; that from age or the gradual wearing out of the human mechanism, the exception. Natural decay of the organism, as in old age, or from the derangements or lesions of the vital organs caused by disease or injury are the causes of death in the human subject. The processes actually cease to repair the inertia of all that was capable of motion under life's regime and which is extracted by this so-called natural decay. Cessation of life is death, it is the failure; the living organized body ceases to perform its functions, in whole or in part—it is dead. When the first life ends, and the second begins, is a question that has not yet been definitely settled; during this transition stage subjects have been supposed to be alive, and live subjects have been treated as dead. We hear

now and then of persons having been buried alive who were really and practically dead.

SOMATIC DEATH.—The death of the body as a whole is termed somatic death; this also is the popular idea of the word death. It is the absolute cessation of the functions of the brain, the circulatory and respiratory organs. The time of its occurrence can generally be reckoned by the entire and continuous stoppage of the circulation and of the respiration. General death is of two kinds—death of the body as a whole, which is somatic, and death of the tissues, which is molecular.

MOLECULAR DEATH.—Local death is going on at all times and in all parts of the living body, in which individual cells and elements are being cast off and as fast as they are so cast off they are replaced by new cells; this is one process that is essential to life. When death takes place the body as a whole dies first; there is an entire disappearance of the vital actions of the ultimate structural parts of the body. But the death of tissue itself does not occur until after a considerable interval, for it should not be forgotten that life in the ordinary signification of the term continues for some time after death, not only in the muscles, but also in other tissues, as well as in the vibratile cells of the epithelium and in the movements of the cells and germs; this may continue for one or two days. This is called molecular life and manifests itself after somatic death; were we to know when it occurs, we would then know the exact time of death; by this I mean to say the exact time of the cessation of molecular life, for certainly complete molecular death is the true and scientific death of the human body, for molecular death may be partial as well as complete. Molecular death may attack a part, a tissue, or an entire organ, without causing a general stoppage of the circulation. The part of the body thus affected becomes obedient to the operation of the ordinary chemic and physiologic agencies which govern the inorganic molecule. An incessant disintegration of tissue may occur without interfering with the general stoppage of the circulation; the active processes of life being manifest throughout; this is pure molecular death in part. That part of the organism in which it takes place may or may not throw the whole mechanism of the human body out of gear; the part may be too weak, and thus partial molecular death proceeds; its existence may be

proven by caloricity and muscular irritability, by the post-mortem growth of the nails, of the hair, and occasionally by evidences of nutrition and secretion. Complete molecular death, is caused by a progressive action and a progressive suspension of vital activity, not only in one, but in all parts of the organism, thus we are all at sea as to the period of its occurrence. While efforts at resuscitation in somatic death are frequently rewarded with favorable results, such efforts in complete molecular death are without avail, and the precise moment of its occurrence is likewise an as yet unsolvable feature.

SIGNS OF DEATH.—This subject is one of such immensity, of such depth, and burdened with so many and difficult features, that any effort on the part of any scientist must be fraught with the greatest labor, to be torn with the shafts of criticism, to be rent asunder by the blows of the ever-present aunt, uncle, or descendant of some one claimed to have been buried alive. The scientific world is divided on the reliability of certain or even all of the tests. Death has its phenomena, it has its signs, its reality must be determined by these, a few of them can not be denied, still cases will be reported for centuries to come, where the corpse retains all the features of the living body. The public are to a certain extent familiar with the signs of death, especially the ever-present undertaker; it thus becomes a matter of the greatest concern for the physician and also the lawyer to familiarize themselves with these phenomena and signs of death, with that I mean the precise and unalterable signs of death. For certainly no physician is justified in certifying that a person is dead unless several of the unalterable signs of death be present, and also well marked; life is not always extinct because one or two signs of death are evident, still I say that it is the rarest thing in the world, not excepting anything, for the physician to be placed in any doubt as regards the actual presence of death. Although the question of whether death is real or apparent is oftentimes one of great difficulty to the ordinary layman who in these days is allowed to settle this point, still very few cases of suspended animation are on record as being buried alive. There has been, however, among the people of all countries, for all time, a dread of being buried alive. It has become a nightmare to some, haunting them until cutting of the radial has been incorporated as one of

the provisions of their will, to be carried out after death, in order to prevent live burial. This is an unreasonable fear which haunts men, women and children. The physician can and should tell the families of the departed that he has discovered unmistakable signs of death, and thus assure them that life is extinct. This fear has been augmented by sensational reports of bodies being dug up where it was discovered that the position of the body differed from that which it had when lowered into the earth. This causes the friends and family to believe that life had not been extinct at the time of sepulture. The danger of live burial is reduced to the minimum, as I believe that any physician can determine the existence of death, and in all cases reported of live burial, I am quite certain that had a physician seen the body he would have detected whether there were any doubtful signs or not, for there are certain signs of death which are known to the medical man which are, in my opinion, past all argument to the contrary. These signs are also known to laymen, and are conclusive; thus the danger of live burial is reduced to the smallest possible chance—in fact, I do not believe that it occurs. An error of judgment is possible, but the watchfulness of family, physician and friends in these days precludes any such possibility. For certainly the signs of death are as definite and as positive in a few hours after death as they are in a few days; still we must not set aside this matter so lightly until we get more positive signs of the reality of, and the explicit presence of death. Physiologic discernment must be brought into play, in the determining of the reality of death. The action of vital organs is frequently suspended, producing every appearance of death; by proper manipulation they may be restored to activity. The most common test which is to ascertain whether breathing has stopped or not is invoked by all classes of persons, in all walks of life; breathing has been known to stop for hours in cases of suspended animation, and so on through all the signs of death. It has been claimed from the times of the Grecian and Roman philosophers that there was no certain sign of death or of the cessation of life. It is almost a physical impossibility to provide for the making of all the tests known to science, on any single corpse, still no one test in itself is sufficient; they are to be taken collectively. The great need of the day is the possession of some simple test,

an infallible test, one that can be applied by the physician at the bedside, at once, and before the certificate of death is filled out. The test I have in mind is one which applies to the circulatory system, and in my opinion it is infallible; yet, although recommended and used for many years, its infallibility has been questioned, although no cause therefor has been given. I will refer to this test as one which can be applied immediately. It is positive, it is reliable and, in my opinion, can never fail. I claim this as a simple and sure test of the departure of life from the human or any other body.

To determine by tests whether the bodies were those of dead persons or of persons apparently dead, I undertook to apply the foremost and best tests known to science on the bodies of 7900 persons, males and females, young, old, and of all conditions of life and nationalities. These observations comprised the time between March, 1882, and December, 1898, almost 17 years. The modes of death in these cases were by disease, old age, homicide, accident, suicide, and still-births. It was not always easy to determine from the histories of the cases when death had ensued, but to my own knowledge death had existed all the way from one second to eight months. I saw the bodies in all the stages that follow dissolution, in cold weather and in the heat of summer, in private residences, in the morgue, on the highways, in fact in all conditions and under all circumstances. The phenomena of vital existence give way to the phenomena that accompany death, rapidly in some cases, slowly in others.

We are all familiar with the scientific fact that decomposition may take place before death—namely, in gangrene of the lungs or of the extremities. We know as well that bodies may lose their heat before as well as after dissolution. We know that motion and sensibility may disappear before the respiration and heart beat cease. We know that bodies become rigid in some instances before death, and still these phenomena are those of death although they do occur in life. Valuable incentives have been offered for the discovery of some sign of death, certain in application and unfailing in its conclusions. In my observations which will follow in the succeeding pages, I believe that among all the signs of death two are infallible, the tests therefor being equally so. One test is so simple that it can be applied immediately after the cessation of respiration and the

heart sounds; the other sign appears after the disappearance of rigor mortis. The tests I employed were some of them very old, others were of more recent date. Usually all the combined signs of death are considered as a criterion; I am certain that if one of the tests mentioned is used there will be no necessity for the use of any of the others, as I believe that this one sign is reliable and never failing. The signs of death are in the majority of cases as certain and as definite as anything could be. The philosophers claimed that there was no certain sign of death or cessation of life. It has also been claimed that persons have been buried alive; I venture to say that now no medical student could be tripped up on a case of apparent death; as for persons being buried alive, if any such have occurred, they must have been in instances where no physician had been called to verify the fact of the cessation of life, consequently the blunders have been popular ones. The signs of death are certainly unmistakable, under the eye of the vigilant student or the practical physician. I will now consider the signs of death and the tests therefor, as I found the former, and as opportunity afforded me to apply the latter. The following order was observed, in noting the principal signs and tests of death.

1. CESSATION OF RESPIRATION—

- a) Mirror test.
- b) Feather test.
- c) Water or mercury test.
- d) Stethoscopic test.
- e) Rhythmic traction of the tongue.

2. CESSATION OF CIRCULATION—

- a) Stethoscopic test.
- b) Ligature test.
- c) Scarification and cupping.
- d) Opening of an artery.
- e) Needle test (Cloquet's).
- f) Fluoresceine test.
- g) Injection of ammonia (Monte Verde's test).
- h) Diaphanous test (Carriere's).
- i) Roentgen ray.

3. CHANGES IN THE EYE—

- a) Test by bright light.

- b) Test by mydriatics.
- c) Test by ophthalmoscope.
- d) Test by ophthalmatonometer.

4. LOSS OF ANIMAL HEAT—
Temperature test.

5. LOSS OF SENSATION AND OF MOTION—
a) Electric test.
b) Heat test.
c) Caustic test.

6. MUSCULAR FLACCIDITY AND CONTRACTILITY.

7. CADAVERIC ECCHYMOSES, LIVIDITY OR HYPOSTASES.

8. CADAVERIC RIGIDITY, CADAVERIC SPASM, RIGOR MORTIS.

9. PUTREFACTION.

I. CESSATION OF RESPIRATION.—In my observations on the seventy-nine hundred dead, this sign was present in all without exception. Thus 100 per cent. of the bodies presented absence of respiration, and in no case was I enabled to produce a respiratory effort. Thus, absence of respiration can generally be regarded as sufficient to determine the reality of death, although this rule does not hold good as a sign of death in all cases; it has been demonstrated by good authority that a child may live and yet show absolutely no signs of life, so far as its breathing apparatus is concerned; thus it becomes a very difficult matter to decide whether a child was born dead or whether it died after birth. The fact that on autopsy evidences are found of the lungs having been inflated, is not positive proof that the child was born alive, for it has been proven that children breathe imperfectly before birth. These remarks apply to still-births. Immediately after birth, children may live for hours and even days, without an apparent effort at breathing. In such cases, partial or bronchial respiration takes place. There are cases recorded, although they are very rare, of children living twenty-four hours with complete absence of air from the lungs. Resuscitation did not follow any of the efforts made in my series of cases, although persons have been resuscitated, when apparently breathless; in so-called still-births, breathing has been produced in numberless instances, still in 160 cases that I have experimented upon, in not one instance was I able to produce natural

respiration. I made attempts in these cases lasting as a rule five minutes; if no respiratory movement could then be produced, I marked the case as certainly beyond hope. I consider that the continuous cessation of respiration may be regarded unequivocally as indicating death: at times it may be difficult to determine positively whether respiration has ceased. The respirations may be infrequent or they may be shallow. Any longer suspension of respiration than five minutes must in my opinion prove fatal, for the very simple reason that respiration is an act of vitality. It is claimed that some persons can hold their breathing apparatus in abeyance for minutes at a time, but did you ever hear that any one attempted suicide in this manner, and if it was attempted did any one ever succeed? Respiration is one of the most essential of vital acts, consequently its permanent suspension is a most positive sign of death. Usually, respiration ceases some seconds, in some cases some minutes before the heart's action, still the stoppage of respiration is not in all cases to be considered as a sign of the disappearance of life; from this we must conclude that the moment of death can not be reckoned as being identical with the cessation of respiration. When all the usual signs of breathing are absent life may still be present. Some of the conditions associated with stoppage of respiration are matters of common observation, even with the most ignorant. It is necessary in all cases, not only to ascertain whether breathing is extinct, but also to determine whether the lungs have actually lost their power of being revived. Suspension of the function of respiration can be restored, when occurring as a result of certain conditions, but when absolute stoppage of this vital act occurs, no power on earth can restore that function. The tests applied, in my series of 7900 cases, were as follows:

(a) *Mirror Test*.—An ordinary pocket mirror was suspended over the mouth and nose, this was done in all of the 7900 cases in order to collect any traces of moisture which might escape through the act of breathing, but not through any other processes. The mirror in every case was cold; the mouth of the corpse was forced opened when possible. The mirror must be held either close to the lips, or anywhere from one to six inches therefrom; in the majority of cases it was held at a distance of one-half inch, for a length of time anywhere from

half a minute to one hour. This test has been used from time immemorial, and is simple, but unreliable in the highest degree. Moisture condenses and dulls the mirror's face, the presence of moisture may prove life, but its absence does not prove death. In 39 cases of the 7900, this mirror test was disproved, in that the face of the glass became covered with moisture, and was soiled; this moisture and soiling was produced by the evacuation of gases. In none of the cases was moisture found on the mirror, where it could in anywise be attributed to breathing, although in 781 cases it was held or placed over the mouth and nose for the space of one hour. Although in cases where decomposition had already taken place, it was useless to try this test, still it was used, the object being to get the condensation of vapor from the gases of decomposition.

(b) *Feather Test*.—Suspending a feather before the mouth and nose of a corpse, or placing a piece of cotton-wool, on the lips to detect currents of air and the absence of movement in these two processes is considered an indication of the stoppage of breathing; in 420 cases in which I used this test, movements were detected in 180, but these movements were imparted by surrounding currents of air. This test is as untrustworthy as the mirror test, and no positive conclusions should be drawn from the use of either of them.

(c) *Water or Mercury Test*.—The standing of a glass of water, or quicksilver on the chest of the dead person. I used this procedure in 378 cases. It proved as unreliable as the two former, in that contractions of the diaphragm and probably of other muscles of the body produced a disturbance of the surface of the liquid used, in 17 cases. In one case of death caused by cancer of the omentum, an actual movement of hiccough occurred, without the audible sound; this continued for some time after the respiration and circulation had ceased. In this case the water almost overflowed from the movement imparted to it by this post-mortem phenomenon. A shallow vessel may be used instead of a glass, but in any event this test is unreliable.

(d) *Stethoscopic Test*.—Auscultation with the stethoscope was performed in 1406 cases, but in no case was a respiratory sound heard.

(e) *Rhythmic Traction of the Tongue*.—I practised Dr. Laborde's system of rhythmic traction of the tongue in all cases dead

less than two hours. As far as I could ascertain I got no response in any case. It was continued in some instances for twenty minutes, in one case for two hours, especially in cases of still-birth, which numbered 160, but in none of these did I get the least encouragement.

Movements of respiration are sometimes difficult to observe; they may be going on and still not increase in depth or in frequency by any process that may be used: all tests may be used and still no response be had. Certain animals during the time of hibernation breathe so infrequently and so superficially that the most acute observer may be nonplussed. Respiration may cease for a short time and be consistent with life; entire stoppage does not preclude life, entire and continuous stoppage of respiration does.

2. CESSATION OF CIRCULATION.—The suspension of the cardiac function has been noticed by many observers in cataleptic, lethargic, syncope and trance conditions. I have never met with any of these cases but that I could discern an audible heart sound. Like respiration, if cessation of the heart were absolute dissolution would follow inevitably, for certainly life can not continue without circulation. Like the respiratory movements, the movements of the heart may be very slow and infrequent. Continuous cessation of the cardiac function precludes all possibility of a return to life; it may be regarded unequivocally as indicating death, still it is very difficult at times to ascertain with certainty whether the heart is beating or not.

How can we conceive of a human being living for twenty, forty or sixty minutes without breathing, without circulation? The beat of the heart may be reduced like the number of respirations—that is, to a minimum, as it occurs in head injuries, or in certain neuropathic conditions—but a continuous stoppage of the circulation means death. The absence of the pulse at the wrist does not denote absence of circulation, for the heart may still be beating and resuscitation may be possible; even with the finger on the radial no impulse is felt. But when the heart ceases to beat death ensues. The heart may beat but four, six or eight times a minute, as it does in the hibernating animals; this is also possible in human beings but if the cessation of the heart's action be entire and continuous, then it can be taken as a certain sign that life is extinct. Vitality may be reduced to the lowest

ebb, but the sounds of the heart can always be distinguished. Absence of pulse may occur in many diseases and conditions, but the mere absence of the impulse of the heart at the wrist does not denote in all cases a cessation of the action of the heart, either temporary or continuous; the heart may cease its beating for a time, and then after a brief interval recommence its action. Such cases have been reported in which the heart recommenced its action after intervals of rest of twelve and fifteen minutes. Heart pulsations have been produced, so that they became perceptible fifteen to thirty minutes after an apparent still birth, but in no case have I ever seen such a result. Where the vital energies are reduced to a minimum, not only do the heart beats become reduced in number, but their characters are lost. Thus in cases of profound sleep, or in cases of so-called trance, in the human subject, the action of the heart is slowed, and its impulse at the wrist, or as heard over the cardiac area in the chest, may become so feeble as to escape the notice of the medical examiner. But if auscultation be practised carefully and long, at intervals, of a few minutes at a time, the heart's action can be detected. These conditions of profound and long sleep, may be accompanied by a rigidity simulating cadaveric rigidity, especially when it occurs in women and young girls. This is a pure counterfeit of death. In these cases also, the use of the stethoscope will detect the heart's action, infrequent and feeble as that action may be.

Sleep may be so profound as to last days and nights, becoming deeper and deeper. The skin in these cases may take on the appearance of death. The limbs may become rigid, the secretions may cease to be manufactured, that they may become suppressed, but the feeble impulse of the heart is always present and can be detected by the practised ear, together with the assistance of the stethoscope.

In cataleptic conditions, where there is a coldness of the surface, a pallor of the skin, an almost imperceptible pulse at the wrist, with rigidity of the limbs, with the eyes dulled, and unchangeable to light, with respirations infrequent and almost imperceptible, in fact a puzzle to the most scientific—in these even auscultation will detect the heart's sound. In fact, throughout all these cases that have been reported, the action of the heart has been detected by careful and painstaking stethoscopy.

When cessation of the action of the heart is permanent for an unreasonable length of time, life is certainly and unequivocally extinct; continuous stoppage of the action of the heart can not and never will be overcome, by any means known to us or to future generations. It is therefore in my opinion a criterion of certain death. I will agree that the simple placing of the finger on the radial is not sufficient, to ascertain death, still in how many cases is a further test for death made? The pulse may be imperceptible for two, five, and sometimes one hundred and twenty minutes, if we are to believe in the cases that have been so reported; the action of the heart may be perceptible during these periods of time, by auscultation, then stopping, then appearing again, finally resuming its normal action, or disappearing entirely, consequently the pulse is not as reliable as auscultation of the heart itself. A low form of circulation of the blood may persist for three hours or longer, after respiration has ceased. In these cases, circulation can not be taken as a sign of life, all efforts at resuscitation being of no avail. It is claimed that the heart can beat without being heard by the most expert ear. I do not coincide with this view, as will be explained in the tests made to determine the existence of circulation as performed by me in 1406 cases of dead bodies, the balance of the 7900 being so certainly dead as to make it appear foolish to auscultate for the heart's action. I claim that if continuous auscultation is performed in doubtful cases for the space of thirty minutes, even for fifteen minutes, or at intervals of a few minutes at a time, no error can be committed. The force of the contractions of the heart may be lessened, the frequency of its action may be reduced, still the expert can detect the presence of life by means of the stethoscope. This is the main point to be decided, this question whether or not the heart continues to contract, for it is admitted that the pulse may be entirely absent and still cardiac contractions be present, feeble in the extreme, scarcely recognizable, infrequent, a scientific puzzle in fact, but the stethoscope proves the bulwark, the mainstay of science as applied to medicine. In all these reported cataleptic and trance conditions, in which the friends of the family, and even the physician, note an entire absence of voluntary movement and an to all apparent condition of death, in all these cases, although the impulse of the heart at the wrist

may not be perceptible to the touch; the ear to the chest may not detect the characters of the first or second sounds of the heart, yet the careful auscultator, with the improved instrument, can settle the point whether the heart is at a standstill or not. The characteristic conditions attendant upon instances of catalepsy and trance overshadow to such an extent the signs of real death that error is the extreme exception. When the heart actually ceases to act for twenty minutes, in my opinion, real death is certain; for the heart is the last organ to die. Cessation of breathing is more apparent to the medical attendant than cessation of the circulation, the former taking place some minutes before the latter; in cases of asphyxia, where the blood being fluid and capable of flowing, means are resorted to to give oxygen to the blood, the circulation and breathing may be restored. In death from disease, however, the blood takes on a more coagulable form, and in these cases no efforts known to science can restore the circulation, much less the contractions of the heart. The entire and continuous stoppage of the contractions of the heart are certainly signs of sure death: while the heart may act in an independent manner for some minutes after the cessation of respiration, it can not be called into action after its entire stoppage. The heart will beat after its removal from the body, it will contract after being cut into fragments and laid on a plate, but it does so from an inherent life of its own. Vitality can not be restored to the heart, after its entire and continuous cessation, by any means known to the scientific or other worlds. Out of 1406 cases in which I attempted to restore the circulation, of the 7900 experimented upon, in not one case did I get a response to the general or to the local circulation, with all the tests that I used.

(a) *Stethoscopic Test*.—It were vain and almost foolish for the physician to apply the stethoscope to the detection of the heart sounds in a case where rigor mortis had set in, or in the first stages of putrefaction, immediately after rigidity had disappeared. I used the stethoscope in but 1406 cases out of the 7900 examined. In these I was informed that death was recent. The region of the heart was examined carefully throughout its entire area, and in no case was any semblance of the heart sound discovered; the surrounding auditory conditions were as perfect as I could well make them by excluding all outside noise

influences. In the majority of these cases the entire region of the chest was examined, to ascertain if there perhaps might be a sound from a displaced heart—displaced upward, downward, to the right or backward. In some of these cases auscultation was practised for hours, at intervals of time ranging from five to thirty minutes. Many of these tests with the stethoscope were undertaken on the bodies of the drowned, in which cases it has been reported that the heart may beat thirty and even sixty minutes after respiration has ceased. In all my observations such an occurrence never showed itself, though in quite a few of the bodies the stoppage of respiration, through immersion or submersion, had occurred but a few minutes before my stethoscope was applied. Neither did I find that any of the cases were in a condition of trance, syncope or catalepsy. In cases of asphyxia, from other causes than drowning, where the blood is supposed to be very fluid after death, of which I have seen quite a number, and where it is taught that the blood is in such a condition that it will flow easily, I was never able to detect a sound over the cardiac area, even after all recognized efforts had been made to resuscitate. It has been recommended that the heart should be examined for thirty minutes, without taking the stethoscope from the cardiac area. I have tried this manner of listening and finally could hear heart beats, but they were the beats of my own heart. I could also hear any number of indescribable sounds that could by no manner of reasoning be ascribed to the action of any heart. The experimenter must have a well trained auditory sense, he must be accustomed to auscultate every day, as it were, in order to detect the feeblest sound in the chest. One may hear absolutely nothing, another auscultator will claim that he hears sounds, still they can not be ascribed to the action of the heart. Faint movements of a weak heart may escape the auditory senses of some; in fact, the right side of the heart may contract for some time after the left side has ceased its action, but to the expert auscultator even this becomes apparent. The discovery of heart sounds in doubtful cases requires some degree of technic skill, which can only be attained by the constant and careful use of the stethoscope: not for an instant only, but for minutes, say five to fifteen, then resting, and re-examining. This is advisable in all doubtful cases. If after careful

stethoscopy, cessation of the heart's action is absolutely established, then it is useless to go any further, it is then almost absolutely certain that death has ensued. I doubt that the careful medical man can make any error in this conclusion. Furthermore, there can be no doubt that this test of stethoscopy is one of the best tests to distinguish between real and apparent death. Taking into consideration the fact that the sounds of the heart may continue in a very slow and weak manner, the microphone, or the phonendoscope may be applied in addition to the stethoscope. In all my experience it seemed to answer the purpose, and I hold it to be a reliable and certain test.

(b) *Ligature Test*.—From childhood's tricks, we know that when a string is coiled about the finger, that the part beyond the string becomes blackened. This test has been awarded a prize, but has not earned its reputation since. This method results with the living body in producing a stoppage of the circulation; in the dead body no change in the color of the skin is observed. This is perfectly natural and reasonable. If the finger or the lobe of the ear be bound tightly, with a ligature, that part of the finger or ear beyond the point of constriction will, if the person be alive, become of a bright red color; this color increases in depth until it finally assumes a uniformly bluish red tint, and on looking further a narrow white line may be seen where the ligature constricts: but if a ligature is applied to the finger or lobe of the ear of a dead body, no such changes are noted. This has been considered a certain test of death as regards the circulation; it indicates in all cases whether circulation persists or is entirely absent. This test is especially valuable in cases where the heart beats slowly and feebly, for certainly if there be any circulation in the ends of the fingers or lobe of the ears, the ligature will produce a congestion at the point constricted. If life be extinct no change will be noted. This has been counted an almost infallible test by some authorities in ascertaining whether there be a continued circulation present. When in a decided hurry to use this test, a piece of worsted will answer, applied around the base of one of the fingers, or lobe of an ear, and left in place for about fifteen minutes, or even half an hour. If there be a continued flow of blood, the finger will swell beyond the ligature, and become dark in color, and on cutting the ligature, the tightened skin

will be found colorless. A ligature of any material may be tied about the arm at almost any point; if circulation be continuous, the veins will swell below point of ligation. This test can be used by lay persons to determine whether circulation is continuous or not; it may be applied to fingers, toes, arms, legs or ears. If circulation is present, no matter how feeble, the part ligatured, in the course of a longer or shorter period of time, assumes a livid tint from the effects of strangulation and the damming back of the contents of the venous vessels, while a ring of anemic whiteness will form at the point of constriction, due to the pressure of the ligature on the superficial blood vessels. I used this ligature test in 987 of my cases, and in no instance was any change noted; in 182 cases I used this test on one or the other ears; in 776 cases I used it on the fingers, and in the balance of the cases I applied it to the arms or legs. I hold this test to be reliable (in so far) as it will indicate any circulation in the parts ligatured.

(c) *Scarification and Cupping*.—This test is that in which scarification and cupping are employed, in order to ascertain if the blood flows. If used immediately after the subject has ceased respiring, and before any effort is made to ascertain whether circulation is going on or not, the chances are that blood will flow, simply through and by the mechanical features of the test; in fact without using the cupping glass, or the scarificator, we know that blood will flow from wounds on dead bodies hours and sometimes days after death, especially if the bodies are placed in warm rooms, or during the process of putrefaction. Such phenomena can and do take place. Flowing of blood may take place as long as eight days after dissolution. This is an important fact to know and can be attested by any one who has performed sections on corpses, in which the first incision through the thorax brings blood, in some cases flowing in large quantities. If such a phenomenon takes place then, why not from cupping and scarification? The fluidity of the blood, the flaccidity of the veins, the position of the dead body, all these tend to force the blood to the surface and out into the external world. These points are very important in this connection, and certainly ought to do away with this test as one regarded of sufficient importance or interest to be connected with the circulation of the blood. Capillaries may burst in dead

bodies and take on the same aspects as hemorrhages of the same size in living bodies. I have noted this in eighty-nine of my cases. In seventy-one of them I found hemorrhagic spots of varying sizes, situated on the most dependant portions of the bodies of persons found dead on stairways, hanging out of bed, or in dependant positions in streets, etc. Dependancy of position was not a bar in some of the cases, especially in those with impoverished blood vessels, to the occurrences of hemorrhages on abdomen, when found lying on back, or on back when found lying on abdomen. In some cases the hemorrhages are so extensive as to show a free flow of blood when incisions were made into the skin. Blood no doubt retains its vital functions for a considerable time after death. When a vein is opened blood may or may not flow. Mechanical pressure, in the abdominal cavity, exerted on the diaphragm, and on the great vessels, heart and lungs, will drive whatever blood there is in the veins to the periphery. This blood escapes but does not coagulate; it is fluid venous blood. If scarification and cupping are performed on the body, yet warm from its life recently extinct, it ought not to coagulate, but in some cases it does. This is to be distinguished from the coagulation of blood from the living body. Leeches may draw blood from a dead body; I have seen it in one case twenty-four hours after death. This test is applied to determine whether blood will flow after death. It is an absolutely worthless test, and should never be relied on to the exclusion of other tests. I refer to cupping, leeching and scarification as distinguished from letting blood from an artery. The opening of veins in dead bodies may show that the blood is fluid or coagulable, also an obsolete test, and happily so.

(d) *Opening of an Artery.*—In the series of tests made on the 7900 bodies of the dead, I cut down on the radial or temporal arteries in 1572 instances. As is well known, blood from any ordinary cut or wound in the living subject will coagulate on exposure to air, whereas the blood from the dead subject is watery and lumpy, and does not coagulate. Feeble muscular contractions of the heart will cause the blood to flow to the radials and temporals, even when there may be no pulse perceptible, and I hold that the opening of the radial or temporal arteries will demonstrate infallibly, and without doubt, the exist-

ence of the least life in the human body. The arteries of a dead person are likened to empty india-rubber tubes: if there be any circulation at all, no matter how slight it may be, blood will be found in the arteries, pumped there by the heart muscle. No cataleptic or trance subject, no person in profound sleep, nor with suspended animation, could exist for more than one hour with an artery exposed and open, so that the blood could flow from it. This is a certain and infallible test, and in my opinion should be practised on the bodies of all dead persons. The first incision would prove life or death, during the process of embalming. The very operation of forcing the embalming fluid into the body precludes any danger of forcing it into the arteries of a living person, for blood certainly would flow from the arteries as soon as they would be opened, and here the operation of embalming would cease. The arteries of the dead are empty and nothing flows from them when they are opened; the embalmer takes this as a sign to proceed and he does so. The arteries are pale or yellowish, and completely empty after death; during life, the arteries pulsate, and they have the color of the tissues surrounding them. In cases where the arteries have become rigid from any diseased process this latter condition does not obtain. If the heart be beating, section of any artery, preferably the radial or temporal, would be followed by a spurt or flow of blood. I hold this to be the most reliable test of the condition known as death. No better test can be employed; as an immediate and satisfactory test the cutting of an artery is supreme. Especially is this the case after auscultation of heart and lungs reveal nothing.

(*e*) *Cloquet's Needle Test*.—This test is the one in which needles are employed by being thrust into the muscles. A clean, bright needle is used for this purpose, the theory being that if the needle is stuck into the muscles of a living body, it will rapidly oxidize, rust or tarnish, but if the needle is thrust into the muscles of the dead body, it will neither become oxidized, rusty or tarnished. This applies also to the fact that if the needle is left in the tissues of the living body but an instant, it will be affected the same as if it were left there for hours, whereas if it be left in the tissues of the dead body for hours, no effect will be noted—on the contrary when removed, the needle will look as bright as when thrust in. In making this test it has

been noted that much depends on the extent of the cooling of the dead body. I used this test in 202 of the 7900 cases, and in twelve instances the needle became oxidized on its removal, showing conclusively that the test is worthless. I preferred the biceps muscle in my tests, and in all the cases plunged a bright, steel needle deeply therein.

(f) *Fluorescin Test*.—A hypodermic injection of fluorescin, under the skin, will, if a person be alive, be distributed over the body, but if it is used on the dead body, only the space about the spot where injection is used will become colored. Fluorescin is a substance used for purposes of dyeing, and is a very powerful coloring matter: a milligramme is sufficient for the test. This test is an almost unnecessary one when other tests are considered, in determining the existence of the circulation: it was used by me in seventy-two cases, and in all there was a spot of color around the hole made by needle.

(g) *Monte Verde's Test*.—Injection of Ammonia.—If during life a solution of ammonia is injected under the skin, a mark or congestion of a port wine color is set up in the surrounding tissues, no such color appearing when the same solution is used in the same manner in the tissues of the dead body. This test in my experience has not always resulted in a positive manner. In 197 cases I injected a solution of ammonia into the tissues of dead bodies, some rigid and partly decomposed among them. In those dead but a very short time, as regards circulation and respiration, the port wine mark was as evident as if they were alive. In twenty-seven of my cases I noted the port wine congestion mark, although the radial had previously been divided. But it was noted that the longer life had been extinct, the less apparent became the so-called port wine mark; in this manner data could be collected from which one could formulate the time which had elapsed since life ceased. In some of the cases it was a dark brown, in others a dirty brown color, depending entirely on the length of time since dissolution began. If ammonia be injected in the tissues of the living body, the discoloration produced is of a distinct port wine hue—this is claimed as indicative of life: whereas the dirty brown stain is said to indicate the beginning of decomposition in the tissues. The absence of the red blotch under the skin after the subcutaneous use of a solution of ammonia may be taken as a sign of death, pro-

viding the test is made some hours after death. This test I can not look upon as reliable unless rigidity or decomposition were present, in which cases no such test is needed. Before these changes occur, we have already had recourse to the opening of the radial or temporal arteries, which to my mind is the most reliable and unfailing of all tests, and can be used immediately after respiration and cardiac action have ceased.

(h) *Carrière's or Diaphanous Test*.—When the hand of a living person is held before a strong light, with the four fingers and thumb in contact with each other, or even separated from each other, but extended, a certain transparency, familiar to all, is apparent; but in death this translucency is absent. This is the popular opinion. The presence or absence of this phenomenon is supposed to relate to the presence or absence of circulation. Transmitted light after death would give the part a marble-like and opaque appearance; before death it has a certain transparency and rosy hue. This so-called *diaphanous test* is supposed to be a criterion of death, but to me it is unreliable and faulty. I applied this test in 478 of my cases, not only with powerful sun light, but also with powerful reflectors, which gave an excellent and penetrating light, and in fourteen of the cases the rosy hue or tinge was apparent between the fingers as distinct as if it had been my own hand. The diaphanous test is not a trustworthy one by any manner of means. When applying this test, the light must not be held more than five inches from the fingers. A lighted candle, gas lamp or electric jet may be used. Furthermore, the test must be used on semi-transparent parts of the body, such as the ears, fingers or toes, and if light is not as powerful as it should be, a magnesia lamp may be substituted. At times you will find this so-called red line of life in the dead body as distinct as in the living person.

(i) *Röntgen Ray*.—No matter what information the radiograph may give us as to the signs or tests for death, that information can be no more certain than the cutting of the radial, or the beginning of decomposition. Tests have been made with the radiograph to test the reality of death. A Röntgen ray photograph is made of the chest of the dead person, so as to include the heart in the picture. An opaque object with oscillating edges (like the pulsating, living heart), if interposed between an X-ray tube and a photographic plate, will leave on

the latter a shadow print with light-toned margins. Hence, in a radiograph of a living heart the contour is light and indistinct, and merges gradually into the dark main mass of shadow. In a dead body, on the other hand, the edge of solid thoracic organs, as the heart and diaphragm, is sharp and lacks the dim borderland that marks pulsating movement. I have not as yet used this test, and think it superfluous, for a pulsating and oscillating heart may be detected by other and simpler means.

3. CHANGES IN THE EYE.—With the cessation of the circulation and consequent abolition of all arterial pressure and tension, the eyeball becomes less tense, in fact loses its tension, becomes softened and flattened, and also wrinkled. These physical qualities take place from the absorption of the aqueous humor. There is a perceptible loss of tone in the globe, also absence of elastic resistance. During life the eyeball is elastic and resists pressure, but after death it collapses, sinks in its socket, and becomes flaccid and buttery, as it were—in fact, so much so as to retain dents and marks of any pressure to which it may have been subjected. This condition of the eyeball comes on in most cases twelve to fourteen hours after death, sometimes sooner. Still there may be loss of tonicity during life. Thus, in old age, the globe may sink into its socket. Various diseases of the eye, or of the general system, may produce the same result, especially when there is great exhaustion. When the heart ceases to beat, circulation ceases in the globe of the orbit, emptying the blood vessels, causing the loss of tension spoken of. This is counted as a certain sign of death and as a proof that the heart is not beating.

In 128 cases of the 7900, I observed that the eyeball became larger and harder; especially was this the case in instances of death by drowning where the eyeball absorbs water. Furthermore, the eyeball may become preternaturally prominent after death, having the appearance of the globe being pressed forward; this is in some cases due to the development of gases within and behind the globe. The cornea becomes opaque and milky in consequence of this; the lustre of the eyes disappears; there is no sensibility to the cornea; touching the cornea is a common mode of testing its sensibility; this is always found after death, but it is also found during a certain stage of epilepsy, also in certain injuries of the skull and contents. The loss of lustre

in the eye, just spoken of, sets in speedily after, and depends on the formation of a thin film of mucus over the surface of the eye; after a time the cornea itself becomes perceptibly milky and opaque. Thus it is easy to perceive that the eye may lose its lustre during life, as we are all acquainted with a condition called opacity of the cornea; and on the other hand, the eye may not lose its lustre for a long time after death, especially as seen after death from apoplexy, also after death from poisoning by oxide of carbon and the compounds of cyanogen. The collapsed and wrinkled cornea, covered by tenacious and glairy mucus, also covering the conjunctiva and producing a loss of translucency, I have seen frequently as an accompaniment of very recent or impending death. The conjunctivæ present changes soon after death, the eyelids lose their elasticity and tone, gray, cloudy discolorations rapidly changing to black are observed upon the conjunctivæ and are soon followed by similar changes upon the internal surfaces of the same tissues: these changes are due to films of mucus, or to processes of putrefaction. The cornea is insensible to touch, or other influences, attesting, in the opinion of some, the reality of death. This loss of sensibility of the eye to light is characteristic as a sign of death, and still it may happen under other conditions. Soon after death the conjunctivæ exhibit externally gray, cloudy discolorations; as mentioned before, these rapidly become black. They are due either to the formation of films of mucus or to cadaveric imbibition dependent on the changes incident to putrefaction. These stains spoken of are on the exterior, and are closely succeeded by stains on the interior of a similar nature, and, as some celebrated scientist has said, "the two spots extend and approach each other, forming the segment of an ellipse." I examined the eyes for signs of death in 7607 of the 7900 cases, and in 92 of them the characteristic signs mentioned were absent—I found neither the opacity of the cornea nor the loss of tension. Thus in 92 cases, loss of lustre, softening of the bulb of the eye, and the appearance of black spots on the white part of the eye were absent. In the majority of cases the iris dilates and remains so; being a muscle and one of the smallest in the human body, it loses its reflex movements, and, like any other muscle, becomes flaccid; consequently the pupil which is formed by the circular

iris reacts to light or other influences no longer—it dilates at the moment of death, to the extent of 5 or 6 millimetres. The pupil neither contracts nor expands to light, but certain poisons and affections of the brain affect the pupil in a similar manner. The pupil may dilate so widely as to present the appearance of no pupil, or absence of pupil. The black spot on the sclerotic, outer corner of the eye, is another phenomenon of death, and has been noticed by me in 89 cases only. It is at first very small, but gradually grows larger, moving down toward the lower border of the cornea, or the angle of the eye, where it remains, finally attaching itself to the cornea, with the convexity downward; after becoming fixed it grows larger, and in this way may be an indication of the time since death ensued.

(a) *Test by Bright Light*.—This is accomplished by placing a bright light on one side of the eye, so that the focus of light may be concentrated on the pupil. This is done to ascertain the contractility of the pupil. The light may be moved in different directions, up, down, or from side to side, shading the eye at times, and concentrating the light rapidly on the pupil. I tested 871 of the 7900 cases in this manner and in no case did I get reaction of any kind; of course, it is a scientific fact that no reaction takes place in some diseases. According to some authors, reaction to light, or rather non-action, proves nothing, unless we take it in with the bulk of the other phenomena of death. Commonly it is considered sufficient to hold a lighted match before the eye, which will cause the pupil to contract as much as any other light. The change in the size of the pupil from dilatation to contraction is regarded as characteristic of vitality; but very soon before death, the iris, muscular in structure, and with the properties of other muscles, loses its power of contractility.

(b) *Test by Mydriatics*.—Atropin, eserin and a few other powerful alkaloids, have peculiar physiologic effects on the pupil of the eye of the living person. This action ceases with the cessation of life: the pupil of the eye then loses its responsiveness to mydriatics. I tested for the reality of death, in forty very recent cases, in fact in those cases where I happened to be at the death-bed, and in no case did I get any response with atropin. Thus can the reality of death be tested by drugs dropped into the eye, for the purpose of getting a contraction or a dilatation of the

pupil; these drugs are supposed to have no effect on the muscle of the iris after death, but, since starting this paper, I have seen the pupil in a dead person dilated appreciably by atropin. I therefore count this test as worthless, and have come to the conclusion that if these mydriatics are used shortly after death, we may in rare instances get a response.

Thus I have seen that dilatation of the pupil does occur after death, which is explainable by the fact that the iris becomes flaccid as soon as and sometimes before death occurs. It has been held that the circular shape of the pupil, during life, is uninfluenced by pressure brought to bear on the globe. After cessation of life, if pressure is exerted on the globe, it may affect permanently the normal roundness of the pupil. This also is a theory that does not hold, as in seven instances in life I have seen the pupillary roundness changed by pressure, by synchronous compression, brought to bear in two opposite directions; in these cases, this test was applied by accident in attempting to close the eyelids. Thus, during life, a certain flaccidity of the iris may exist for a few hours before death, but it is not so evident as that which exists after death has taken place. Is it this flaccidity of the iris, then, which causes the dilatation of the pupil as soon as life ceases? This is a constant occurrence, and is a post-mortem dilatation; with it as a phenomenon of death, it is impossible to say what the condition of the pupil was at the time of death.

(c) *Ophthalmoscopic Test*.—This is a procedure that has been neglected to a great extent as a test of real death. As yet observations derived from the use of the ophthalmoscope are very meagre, and consequently its use can not be relied on as a certain test of real or apparent death, but the literature on the subject shows, thus far, that its revelations are very promising. In using the ophthalmoscope the cornea must be very clear, which is a very rare occurrence, as we have seen. The ophthalmoscope applied will show the normally yellowish red of the fundus changed to a yellowish white at death. This is evidently due to the absence of circulation; the red spots in the optic disk are replaced by white spots due to the same cause. After death, the arteries and veins of the fundus oculi are completely emptied; not only does the optic disk show this, but the surrounding tissues also. The fundus of the eye presents a beaded condition

of the veins, due to the presence in them of air bubbles. This is then called pneumatosis of the veins, and is due to the normally imprisoned gases in the venous blood, which become disengaged at death; this causes the column of blood in the veins to be broken and to take on this bead-like appearance. This condition occurs in the retinal veins, and constitutes, according to some authorities, a certain and immediate sign of real death. This sign, it is claimed, can be readily seen with the ophthalmoscope.

The objection I have to it is that it can not be used in all cases on account of the milky appearance of the cornea. Thus, it is claimed, that we can read death, in the human eye, simply by applying the ophthalmoscope, and observing the condition of the veins and arteries, with a certainty of distinguishing real from apparent death. It is claimed that the blood vessels and veins of the retina are least nourished of any vessels in the human body, and that for that reason feeble circulation ought immediately to be noticed, where it exists, when an examination is made with the ophthalmoscope. No doubt the eye does take on an entirely different aspect after death, and an unmistakable one. Within a short time the color of the blood in the arteries and veins entirely disappears. No doubt it may occur just before, or at death, but we are handicapped in using the ophthalmoscope where there is a hazy cornea. Consequently this test is applicable in a certain number of cases only. We all know that the veins and arteries of the retina have distinct differences in color, the veins containing a dark, almost black blood, the arteries, a bright almost crimson. Under the ophthalmoscope these two shades may be distinguished in life, but the opaque film of death precludes the possibility of discerning that the shade distinction has entirely disappeared. Even in cases where it is possible to use the ophthalmoscope after death, it will be seen that the blood in both arteries and veins has been transformed into a pinkish color of a uniform shade. This test has recently been advocated, and in forty-seven of the cases in which I applied it, in all of them the uniform color was apparent. It is certainly a simple and reliable test, and may be recommended in any case of suspended animation, trance, catalepsy, or other condition approaching death, where the eye can be approached with the light of the ophthalmoscope.

(d) *Ophthalmatonometer Test*.—This test has not been used by me in my series of cases, but I deem it of sufficient importance to recount the method of its application. The instrument is the invention of M. Nicati. By the aid of this instrument he has discovered that the tension of the globe of the eye, which he says is normally from eighteen to twenty-one grammes, may oscillate in the physiologic state, between fourteen and twenty-five grammes ($T. = 0.4$ to 1). This tension diminishes with the cessation of the heart beat to twelve grammes, and the lowering of tension, interrupted by rebounds never exceeding twelve grammes, is afterward progressive, until after the lapse of half an hour it has sunk to from one to three grammes; in two hours it is nil. The enucleated eye replaced in the orbit presents the same phenomena.

4. LOSS OF ANIMAL HEAT.—The loss of animal heat is a sign of great importance in determining real from apparent death. At the moment of death there may be a rise of temperature of from $3\frac{1}{2}$ to 7 deg. F.; especially is this the case in death from infectious diseases, when the temperature is taken by the rectum. This rise simply proves that chemical activity continues after death has occurred; as a sequel to this rise there is a lowering of the temperature. The average internal temperature of the body is from 98 to 100 deg. F. This may be increased in consequence of disease to several degrees higher. One of the most remarkable phenomena of life is the power that man possesses of maintaining temperature at 98.6 at an average, no matter what the character of his surroundings may be, whether he be in the tropics or in the arctic regions. This body heat is derived from the potential energy admitted into the body with the food, and also with the oxygen in the respired air. The blood, during and after digestion, becomes surcharged with carbon, oxygen and hydrogen. Part of this goes for tissue repair, and part of the gases combine with the sulphates to generate heat by chemical means, and some of the body heat is generated by slow combustion. Temperature of the body is also generated by the brain, muscles and glands. When the vital processes which generate temperature in the living body cease, as they do after death, there is then a gradual and progressive decline in the body temperature, until it arrives at a degree equivalent to that of the surrounding air. This post-mortem loss of heat seldom falls to a degree less

than that of the surrounding media, unless the temperature rapidly increases in the atmosphere. The body after death ceases to produce or generate heat. It is then nothing but an inert mass, but according to some authorities parts with its heat less rapidly than other media. For instance, a body covered with a thick coating of fat, or covered with clothing, will cool less rapidly than another. Certainly if a person dies in bed, covered with bed clothing and perhaps heat in the room, his body will retain and preserve its heat for a longer or shorter period; there will be less cooling of the body in this case than if the person had died in a cool room and with body uncovered. For instance, a person dies at a hospital, his body is at once removed to the dead house, his external and internal temperatures rapidly decrease. Chemical changes rapidly diminish after death, still there may be a slight rise in temperature in the interior of the body, due to the continuance of metabolic changes in the tissues; at the same time respiration has ceased, consequently the blood can not be cooled, because it can not be sent through the lungs and capillaries of the periphery. Between rise of temperature in the dead body and cooling of the dead body there is complete opposition; the temperature of the periphery is the slower in cooling, thus the temperature externally varies, and must not be mistaken for the superficial coldness of collapse, which implies the cessation of the peripheral circulation only. The coldness of the cadaver, apparent to the touch, is no criterion of the cessation of life, for the simple reason that there is still a certain amount of internal heat that has to be parted with, and the body which is cold to the touch before death may after death show a rise in temperature, due to radiation of the internal heat. Circumstances favor radiation and the conduction of heat in the bodies of the dead the same as they favor radiation and the conduction of heat in inorganic bodies. Cooling of a dead body is slow if the cause of death has been a disease of long duration, as consumption of the lungs, but if death be due to hemorrhage, then cooling of the body will be a rapid process; but if death be due to an infectious disease there will be an initial rise of temperature as soon as death occurs. Is this due to a rapid rigor mortis, or is it due to a continuance of thermochemical or other processes in the body? Consequently cooling of the body is not a sign of death to be classified as positive; it

is the progressive cooling of the body which stamps death as certain. Many conditions may impede the peripheral circulation, drunkenness being one of them; if death takes place during this condition, the spasm in the blood vessels which hindered circulation relaxes, and the temperature as a result of this rises. Cooling of the body is most perceptible in the axilla, but is equalized in some hours all over the body. After death from certain diseases, as rheumatic fever, tetanus, asphyxia, apoplexy, typhoid and scarlet fevers, the body may retain its heat for a long while, and even show a rise of temperature. I have repeatedly observed this, as have other observers. Thus the time occupied in cooling the body may be prolonged after sudden death, and also by the above mentioned causes of death, the body may retain heat for a number of days after death, without any explainable cause; thus the time elapsing since death can not always be reckoned by the temperature. Cooling of the body may be very rapid after death from chronic wasting diseases, hemorrhage and fevers, the external temperature being reduced to that of the surrounding air within four or five hours. The body of a well-nourished person will cool less quickly than the body of a child, or old person. The phenomenon of cooling is modified to a certain extent by the temperature of the surrounding air, protection of the body from currents of air, and the ability of the internal organs in retaining their heat longer than the surface of the body. Thin and emaciated bodies cool more rapidly than others, fat being a non-conductor; a body that is exposed to the air will lose its heat more quickly than when it is enclosed, and a body unclothed will lose heat more quickly than if it were clothed. If the room of death be a large and airy one heat will be given off from the dead body more rapidly than if the room be a small, close and confined one. A body taken from the water loses its heat more rapidly than if it had been exposed to the air. In fact, bodies cool more rapidly in the water than in the air, and more rapidly in the air than indoors, more rapidly when exposed to a draught than in a tranquil atmosphere, more rapidly in a large apartment than in a small one. A large body requires more time to cool than a small one. It is claimed that if a body is exposed in a cold room and the temperature of that body falls to that of the surrounding air, that is to about 20 degrees centigrade, then death is certain.

As far as my experiments are concerned, temperature has proven nothing, for I have known bodies of living persons to be as cold as ice, and not be near death. The heat of the interior of the body may be retained much longer than the heat of the external surface, the internal organs frequently being 10 to 20 degrees above that of the surface. A continuance of molecular life, after the cessation of somatic death, is the cause undoubtedly of heat after death. The rate at which cooling occurs is most rapid, as a rule, immediately after death; this is also the case where a *post-mortem* rise has occurred. The time usually occupied in cooling is from fifteen to twenty hours, subject to modifications which were attendant upon the death. The body may be quite cold in about twelve hours; after the preliminary rise the temperature gradually falls on an average at about the rate of one degree Fahrenheit an hour. During the first three hours after death, the body loses as much as $3\frac{1}{2}$ degrees per hour—many times, less; it then gradually falls until in about fifteen to twenty hours it is that of the surrounding air. Certain conditions before mentioned will influence this cooling of the body, so that the average time within which the body cools varies. To sum up, it is varied by the condition of the body at the time of death, the manner of the death, and the circumstances under which the body had been placed. The average rate of cooling for the first three hours, according to an eminent author, being about $3\frac{1}{2}$ degrees Fahrenheit, which would make $10\frac{1}{2}$ degrees in three hours, then in the next six hours the rate would be 3 degrees per hour, from then on 1 degree per hour; in some cases cooling is complete in five hours, in others not so for twenty-four hours. In the experience of all, it can be asserted that cooling of the extremities exists for many hours before death. Return of color to the cheeks has been frequently observed in bodies of those who, for the purpose of preservation, have been frozen by ice, and on the day of interment they are removed from the receptacle for freezing and placed into the casket for burial, a flush of color ensues not unlike the natural hue of a healthy person; this does not last very long, but passes into the dusky hue of decomposition. In these cases there has been a rise of temperature above that of the previously surrounding media immediately on taking the body from the freezing mixture.

(a) *Temperature Test.* — With the thermometer we can only approximately pronounce upon the time that has elapsed since death. In order to do so even approximately we must take into account all the conditions which modify the rate of cooling of the body, and then we can only state the probable time. We know that cause of death has something to do with the cooling of the body; still, knowing this, we could not infer what actually caused death by the state of the thermometer when applied to the body. Cooling of the body is a less certain sign of death than some others, because the phenomenon of cooling is varied by so many conditions. In making observations the use of the thermometer for ascertaining post-mortem temperature is indicated; the sense of touch is not sufficiently delicate for noting actual coldness, it will detect apparent coldness only. The temperature of the exterior of the body should be noted as well as the temperature of the interior of the same. In taking the temperature of the exterior of the body, the axilla may be employed, although the tension of the gas which forms in the abdomen, after death, drives the blood toward the periphery; thus this part of the body gets a little warmer, but in about 30 hours an equilibrium is established between the temperature of the rectum and that of the axilla. In taking the internal temperature the mouth or rectum may be used to place the thermometer in position. If the temperature of the dead person is taken in the mouth, you will find it lower than the temperature of the surrounding media. Here also, the conditions must be taken into consideration which tend to reduce temperature in the dead body. It has been contended that as the temperature of the skin is always increased during muscular contraction in the living person, by electric stimuli, this absence of increased temperature in muscles would be a sign of death. The thermometer is to be placed upon the skin before and after muscular contraction, and the difference noted. Temperature in a muscle may indicate death, still the heart may beat. Temperature taken in the mouth indicating 62 deg. F. is as certain of death as any sign can be, but is not as applicable as other tests. In from five to eight hours the temperature of the deeper tissues falls to about 80 deg. F., while a few hours after this it may be found to be higher. As regards

temperature, I will say that a continuous and progressive cooling is a more certain sign of death than death certified from an absolute temperature.

The following were the temperature observations made by me in my series of cases. Of course all cases were not subjected to the temperature test for various reasons :

EXTERNAL TEMPERATURE.

These observations were made simply by placing the bulb of the thermometer on the skin of the abdomen, and holding it there.

	2 to 3 hours after death.	4 to 6 hours after death.	6 to 8 hours after death.	12 hours or more after death.
Number of observations	812	709	612	559
Maximum temperature of the body	95 deg. F.	86 deg. F.	81 deg. F.	78 deg. F.
Minimum temperature of the body	59 deg. F.	59 deg. F.	58 deg. F.	57 deg. F.
Average temperature	77 deg. F.	72.5 deg. F.	69.5 deg. F.	67.5 deg. F.

5. LOSS OF SENSATION AND OF MOTION.—The absence of the power of motion, and of sensation, are unimportant signs of death in my estimation. The same conditions obtain in all cases of suspended animation, asphyxia, trance, syncope, apoplexy, catalepsy, and in some diseases and injuries of the skull and its contents. At death, or immediately thereafter, there is a general relaxation of the muscular system, the muscles of the lower jaw, relax, allowing a dropping of that bone. The joints become flexible, the tone of the muscles disappears, but their contractile power remains; moreover, muscles that are contracted by living forces at the time of death, as in cases of poisoning by strychnia, do not necessarily become relaxed in death. Persistence of muscular contractility after death, and the disappearance thereof follow a fixed order, the first parts to present this change being the neck and trunk; next the lower extremities and lastly the upper, while its departing follows the same order. The duration of this phenomenon is shortened by its exposure to warmth and moisture, also to ammoniacal, carbonic, and sulphuretted hydrogen gases; it is unaffected by carburetted

hydrogen, sulphurous acid, and hydrogen gases, nor is it diminished in cases of asphyxia. The continuance of this property of muscular fibre is considerably modified by the nature of the disease of which the person examined died. In cases of persons who had died of peritonitis, it disappeared in three hours, in tuberculosis and malignant diseases in from three to six hours, in death from mortal lesions of the heart, or profuse hemorrhages in about nine hours; these observations correspond to those of other authors. In apoplexy with paralytic symptoms, in about twelve hours, and in adynamic fevers and pneumonia, in about twelve to fifteen hours. Softening or want of elasticity of the tissues of the body which comes on soon after death, is the first of the changes resulting from the destruction of their physical properties. The parts of the body on which it rests will become flattened, and the skin will present the marks of any peculiar figure upon which it may have been lying, and the skin and muscles will not resume their original condition upon the removal of the pressure which, either by the weight of the body itself, or from external sources, has been applied to the parts which show this loss of elasticity. This flattening of the dependent parts has been considered a valuable sign or indication of the reality of death. It is true that this insensible condition of the muscles may exist in life and not lead to death, but the insensibility and loss of power in the muscles that occurs after death is a characteristic sign of death, and occurs in the muscles of the lower jaw, eyelids, limbs and joints, the two latter becoming flabby, soft and flexible. The muscles become hard and contracted as the body cools, stiffening the joints and presenting an unyielding corpse; the muscles may become flaccid and contractile, rigid and incapable of contraction, or relaxed and incapable of further contractibility. Insensibility coming on at death is complete, while that which follows hysteria, or certain general anesthetic conditions, present the same conditions. Loss of motion and falling of the lower jaw have been considered as certain signs of death, but the latter is not a constant sign. At death the muscles become immobile, but the sphincters relax; contractility of the muscles lasts for some time, then disappears; insensibility and inability to move often precede death, and as we have seen occur with disease, do not necessa-

rily produce death. The condition of the muscles of the face at times depicts the mode of death. I have observed this in many instances; it is virtually reading death in the face. The expression of the muscles of the face at the time of death becomes a fixed one—reposeful when killed by the knife, painful when killed by the bullet. After the action of the heart has ceased, usually in about three hours, the entire muscular system loses its excitability. Though the body be dead as a whole, certain parts may continue to retain an independent vitality after this so-called somatic death. This is seen especially in the muscles, which may retain their electric contractility from two to three hours after death.

(a) *Electrical Test.*—The existence of electrical contractility in the muscles of a body supposed to be dead indicates life, or death within a period of two to three hours. The muscles will respond for a certain time to electric or other stimuli for some time after death. The absence of muscular irritability upon application of an electric stimulus of galvanic strength has been laid down as a certain criterion of death. The nature of the disease, which caused the death of the subject experimented upon, exerts considerable influence. To get the irritability of the muscle you must use the galvanic current, though the existence of muscular irritability may be demonstrated by simply pricking or otherwise irritating a nerve of motion leading to the part. This property is usually lost in from eight to twenty hours. I experimented in this manner on the bodies of 402 persons and in 107 irritability asserted itself within an hour, in sixty-seven it showed its presence at the end of the second hour, and in four at the end of the third hour, the balance presented no muscular irritability. The electric current affords almost a certain method of ascertaining whether life be extinct or not, by its success or failure in producing muscular contractions. The shocks must be used at different tensions and intermittingly. Unless it is used skilfully it will fail. The Faradic battery may also be used, by attaching it to an electric needle, the needle being stuck into the muscle to be experimented upon. The most elementary machines may suffice for the purpose; if the same determines on the arm of a living being a slight contraction, and no contraction whatever on the muscles of the face of the dead person, one might affirm that the person is dead, whereas the

muscles of the face are the first to lose their contractility, consequently care must be observed in giving an opinion, as to the certainty of death, in these particular cases; if the slightest trace of contractility be observed the same apparatus should be without delay employed to electrify the heart, and if death is only apparent, one might thus, in restoring the action of the heart and the respiration, restore the subject from apparent death to real life. Cadaveric rigidity being liable to occur before death it is prudent to wait for the first sign of putrefaction before declaring that rigidity and consequent muscular irritability has been absent.

(b) *Heat Test*.—Various means may be employed in applying heat to the skin. Melted sealing wax may be used, for instance, by dropping it upon the skin. A candle flame may be used until a vesicle forms on the skin. I used the sealing wax in forty-two cases without any response as regards sensibility or motion. A needle may be inserted for a quarter of an hour, and for a quarter of an inch, through the skin into the muscle, heating the part protruding with a spirit lamp. If a blister is produced by the application of these tests, and it is opened and contains a serum rich in albumin whilst the cutis vera, after the cuticle has been removed, presents a reddened appearance, more especially if after a short interval a deeply injected red line forms around the blister, absolute evidence is afforded of the vitality of the part to which the heat was applied, and exceedingly strong confirmatory evidence of the life of the person. If a blister formed by the application of flame to the body contains air, or a little non-albuminous serum merely, the cutis vera after the removal of the cuticle appearing dry and glazed, more especially if, after an interval, no red line becomes visible around the blister, the evidence is absolute that the part so treated was dead, whilst the presumption is strong that the person himself was dead. In a dead body a burn may cause a blister, but it will not form an areola. Let a drop of melted sealing wax fall on a limb that has just been amputated, and you will succeed in producing a blister. The test of burning is therefore a doubtful one. Heated flat irons may be applied to the heels of dead persons of whose death it is desired to obtain assurance. Another sign is to apply the flame of a candle at the distance of half an inch from the extremities of the fingers or toes: if death is real

the epidermis of that part of the finger exposed to the flame dries up and separates from the cutis. It forms an air blister, which bursts suddenly with a disengagement of gas which is sometimes strong enough to blow the candle out. This is not a conclusive or certain sign of death.

I have applied this test in 17 cases but have had no positive result one way or the other. A flame held close to the skin will form a blister; if this blister contains serum the person is still alive, but if it contains air only, the person is dead. I have seen a blister containing serum produced after death, in applying alcohol cups for the purpose of ascertaining whether blood would flow after death or not, consequently I hold this as an unreliable test. A burn on the body of a living person usually produces a blister which is surrounded by a reddish areola, and which contains an albuminous liquid. When this blister is opened, a network of small dilated blood vessels is seen. Although this is the usual result, it is not a constant condition in life; for instance, the albumin may be absent from the serum. If the same individual died at the moment he was burnt, blisters are produced, but as a rule they contain no serum and there is no congestion. Heat may also be applied to the skin, by means of a piece of iron or steel, heated red hot for at least the space of a ten seconds. If no blisters have formed, filled with fluid, then death is supposed to be a certainty. I used this test in 72 cases and in six of them where death had positively taken place within three hours, I succeeded in forming blisters.

(c) *Caustic Test*.—If caustic be applied to the skin of those really dead, either no eschar is produced or the skin turns yellow and transparent, but if the caustic be applied to the skin of living person, the eschar produced is of a black or reddish brown color. I applied strong caustic to the bodies of 85 dead persons, and in two of them produced eschars similar to the eschar produced in the living body.

6. **MUSCULAR FLACCIDITY AND CONTRACTILITY**.—We have now a case of a certainly dead body to deal with. What are the first changes that take place, in a general way? The muscles have taken on a condition of flaccidity, their tone has disappeared, they are in a state of inaction as far as voluntary movement is concerned, the masseter and other muscles allow the jaw to drop, the muscles that form the eyelids are so flaccid as to give the eye

the appearance of being half closed, the muscles of the limbs have so far lost their tone that the joints become flexible, and the limbs flabby and soft. To determine whether the muscles are contractile or not was discussed under the heading of *loss of sensation and motion*. This period of muscular flabbiness and softness precedes the occurrence of rigor mortis and must not be confounded with the softness of the tissues preceding putrefaction. Flattening of the soft parts of the body takes place, the parts become very pliable, and may remain in this condition from three to twenty-four hours. Of my 7900 cases observed, I found muscular flaccidity in 1018. This stage of muscular flaccidity produces a more than usually placid expression, with marked pallor; at times a drawn, contracted, painful expression, with reddened countenance, may be remarked. The peculiar sharpness of the chin, and of the nose, the paleness of the lips, the sunken eyes, the temples hollowed out, the cheek bones prominent, the forehead dry, the brow wrinkled, the skin livid, these are the principal and chief features found immediately after death, and are almost characteristic, consequently called by some authorities "*Facies Hippocratica*." Identification of a body may be so difficult, from these changes produced immediately after death, that parents, brothers and sisters are not able to identify their own, and, on the other hand, these changes may be entirely absent after death, or they may be well marked during life. The pale ashy color that in some cases covers the entire body is not a sign of death, for the reason that those dying of yellow fever and other diseases may show the same color. Death-like color frequently occurs in syncope, collapse and chills and fever; reddish color remains for some time after death in those who had in life a ruddy complexion. Jaundiced skin never becomes white after death. Ecchymotic spots always retain the color they had at death, as I might as well say here that the so-called "*Facies Hippocratica*" is an unsafe sign to go by, it is sometimes decidedly absent in sudden death. Pallor of skin is due to absence of circulation, still in all cases of death there is absence of circulation and not always pallor of the surface. Ulcers and burns may show reddened and livid rings around their edges, after death; tattoo marks, the spots of purpura hemorrhagica, bruises and ecchymotic spots also remain.

7. CADAVERIC ECCHYMOSES, LIVIDITY OR HYPOSTASES.—Of this change I noted 7802 instances in the observations which

covered the 7900 cases. Consequently it was noted in nearly all of my cases, either post-mortem ecchymosis, lividity, or hypostasis, singly or combined. This change, which is in almost all cases apparent to the eye, occurs within a few hours after death, and is characterized by the livid and ashen gray tinge, covering the most dependant parts of the body. This is due to the still fluid blood settling in the most dependant tissues, or a virtual stagnation. This phenomenon is also called suggilation. This settling of the blood gives rise to patches which may be separated from each other, but which later run into one. These discolorations are sometimes mistaken for bruises, which can easily be settled by the division of the tissues. Hypostatic congestion is nothing more than cadaveric lividity, when this term is applied to the lungs or other internal organs. This settling or gravitation of the blood takes place during the cooling of the body, and continues sometimes for about twelve hours, during which time, if the position of the body be changed and the blood is still fluid, they may be made to disappear and re-appear. They will then appear in whatever part of the body is the most dependant. This post-mortem staining is taken as a positive and conclusive sign of death, and occurs in death from whatever cause, without exception. It is claimed that when cooling of the body stops, as a result of death, that then the cadaveric process ceases; it probably ceases to form hypostatic, ecchymotic, and livid spots, but the discolored parts of the body become of a deeper hue; this is ascribed to the blood pigment. No doubt the coloring matter of the blood exudes from the vessels into the surrounding tissues. This pigmentary discoloration can not be made to disappear, as the discolorations due to cadaveric hypostases can, they are, therefore, a reliable sign of the fact that death has taken place at least twelve hours before. The bodies upon which I did not notice these post-mortem changes were the bodies of those burnt or too far advanced in decomposition. They are present even in cases of death from hemorrhage, but as a rule not well marked; still in a case of post-mortem hemorrhage seen by me within five minutes after death, I saw the most marked cadaveric congestion in all my experience. These ecchymotic, livid and hypostatic spots occur usually when death is so certain that we need not examine for them. These cadaveric stainings are not the result of

decomposition, they occur long before that process, especially in the stage of muscular flaccidity and contractility, while the body is still warm, and in the process of cooling; as soon as the body has cooled sufficiently, this process ceases. These spots may be of variable sizes, owing to the amount of blood in the vessels, also to the size of the vessels: if at the time of death circulation is very active, then you may expect to find post-mortem staining of a very decided character. Internal hypostasis takes place at the same time as the staining appears on the surface of, or rather the dependant parts of the body. It is held that in dead bodies, not only may ecchymoses become more extensive owing to hypostatic congestion, but capillaries may even burst, and thus produce hemorrhages which differ in nothing from those petechial hemorrhages which occur during life. This is the deduction of the late Professor von Hofmann, of Vienna; he suspended bodies, which were dead twenty-four to forty-eight hours: in these it was possible to produce extreme degrees of hypostatic congestion, but no ecchymosis; but if bodies were suspended a short time after death, taking the bodies of newly born infants for this purpose, small punctiform or streaky hemorrhages were produced in the conjunctiva of the eyeball in from a few to twenty-four hours after suspension, which could not be distinguished from ordinary ecchymoses which had been produced during life. I recently suspended the bodies of three newly born infants, within thirty minutes after death, and noted particularly that they had no hemorrhages on the conjunctiva of the eyeball before suspension, but after being suspended foreighteen hours, I noted the same conditions as were noted by von Hofmann. It is also possible to watch the gradual enlargement of these hemorrhages: in some instances small petechiæ were produced, even in the cortex of the hemispheres of the brain, over the convexity, which looked like those produced by commotion or capillary embolism. Von Hofmann further says that before suspension there was not the slightest evidence of conjunctival hemorrhage in his cases.

This theory of suspension as a cause of hemorrhage into the conjunctivæ is applicable to cases of persons found dead and hanging out of the bed. In such cases, where the upper part of the body was found hanging over the side of the bed, Von Hof-

mann has detected numerous petechiæ in the skin over the chest and abdomen, the shoulders, arms, neck and face of bodies of people who have been found dead, lying in bed with the upper part of the body hanging out over the edge of the bed; this I have noted in four cases recently. He says, further, that it is not necessary that the bodies should be found in a dependant position: even those who are stretched out horizontally on their backs show sometimes, especially when their blood remains liquid for a time, a number of petechiæ on the back and the sides of the chest and abdomen. The fact that these are more often found in old people justifies the supposition that the greater vulnerability of the walls of the capillaries in old people predisposes their bodies to ecchymoses of this kind. Occasionally these ecchymoses are found in the bodies of persons who died of prussic acid poisoning and in children who have been suffering from rickets or acute and chronic gastro-enteritis. It is quite possible that the origin of these post-mortem petechiæ is to be sought in minute capillary hemorrhages which occur in the agonal stage and become visible only after death, owing to hypostatic oozing of blood from minute rents in the capillary walls. If this be true, then the differential diagnosis between post-mortem and ante-mortem ecchymosis will be difficult as long as these hemorrhages are so very small. He writes further that in intra-vitam hemorrhage the blood ought to be coagulated, but that we now know that the blood retains its coagulability for some hours after death, and if, as is often the case, a post-mortem hemorrhage takes place between muscle fibres, it may be impossible to remove it thence with water. But when one finds on cutting into an ecchymosis that the blood clot or the blood flows out by itself, or on gentle pressure, then it is clear beyond doubt that the ecchymosis has occurred after death. During life ecchymoses are much more frequently observed in children than in adults. The same seems to hold good also as regards post-mortem ecchymoses in internal organs; whereas cutaneous ecchymoses are more frequent in adults than in children.

It can not be doubted that occasionally ecchymoses are formed in the lungs, the heart and the thymus, according to the same author, in consequence of the pressure of the blood, which, following the law of gravitation after death, is collected in the dependant parts of the body: but it must also be remembered

that in many instances minute lesions may have occurred in the walls of capillaries during the agonal stage, which after death become larger, and therefore visible to the naked eye. Nothing could be more injudicious than to diagnosticate death from suffocation because a few ecchymoses have occurred under the pleura or the pericardium of children who have been found dead in bed. Such ecchymoses are of diagnostic value only when they appear in parts where there is not, and never has been, any hypostatic congestion, when there are signs of hyperemia and congestion which have existed during life, and when infectious and septic diseases, diseases of the blood and indications of poisoning can be absolutely excluded. The important deductions of Von Hofmann widen the field of research, in cases of suffocation, where heretofore ecchymoses found under the pleura and pericardium have been assigned as positive diagnostic post-mortem evidences of death by suffocation. The blood in a dead body coagulates in the same manner as does the blood that flows from a wound in the living; consequently the position of a dead body may be denoted by the clot found in the interior thereof, the lower portion of the clot being of a deeper color than the surface of the same. The blood is obedient to the laws of gravitation, and congests the superficial capillaries; as decomposition comes on the gases evolved therefrom give the ecchymotic spots a deeper color. These ecchymotic spots are usually situated in the congested capillaries, in dependant parts of the body that are not subjected to pressure; they are irregular in shape, dark colored, and never elevated above the skin; they appear in patches, gradually running into each other; upon incision no effused or coagulated blood escapes, excepting what may escape from the points of the divided veins; when putrefaction sets in these spots are not characteristic any longer and may hardly be distinguished from the bruise on a living body.

8. CADAVERIC RIGIDITY. CADAVERIC SPASM, RIGOR MORTIS.—Muscular rigidity was considered for centuries as a certain sign of death. It is a condition which endures longer in summer than in winter; thus of 3602 dead bodies seen by me in a condition of rigor mortis, 2289 I saw in the heat of summer, and in these rigor mortis lasted from 36 to 48 hours. Rigor mortis is the concluding indication of the positiveness of death. It precedes in almost every case the phenomena of putrefaction, and

comes on generally in from five minutes to four hours after death, though sometimes its appearance is postponed until much later. It does not invade the muscles of the whole body all at one time, it does so gradually. It is a characteristic stiffness occurring in the muscular system after death. In many cases it has passed away before the body has been seen; its time of appearance and its duration differ in every case, it becomes general, that is I have noted so in my experience, it is lasting and generally well marked. There is nothing that can be mistaken for it; the bodies of the dead are usually kept long enough for this condition to appear; this and putrefaction are almost absolutely certain signs of death, although one must wait too long for them to appear. Of course certain forms of rigidity that may occur during life may be mistaken for rigor mortis, as for instance tetanus, rigidity from apoplexy, catalepsy, syncope, asphyxia and hysteria. But in rigor mortis there is no warmth of the body as there is in these diseases; furthermore in rigor mortis there is a gradual stiffening of the muscles, whereas in these diseases the spasm of the muscles is a general one. In the rigor mortis of death, the stiffness usually commences in the muscles of the neck and lower jaw and then gradually affects the other parts of the body. Another distinction between stiffness of disease and that of rigor mortis is that if a joint be forcibly bent in a condition of rigor mortis, it will never return to its former condition. There is a spasm of the muscles, which is usually observed in certain cases of sudden death, as after the more violent forms of death, in battles or from apoplexy, or injuries of the cerebro-spinal axis; this is called cadaveric spasm and may occur after death from any cause, it is simply preliminary to rigor mortis proper. It may at times be indistinguishable from rigor mortis, or it may escape the notice of the observer. It is simply a failure of the limbs to relax at the time of death, no interval being observable between the continuance or departure of the vital tension of the muscles and their fixture by rigidity.

Commencing at the latest instant of life, the rigidity continues, therefore know that flaccidity of the muscles is not a bar to the supervention of rigor mortis, in fact there may be no stage of muscular flaccidity; the stiffness of the muscles proceeds after death in regular order all over the body; the muscles of one part

of the body may be in rigid contraction, whereas the muscles of other parts may still be supple and pliable. Rigidity passes off in the same order as it began, and when once gone, never returns. The body now becomes as pliable as it was prior to this change, and is then attacked by the processes of decomposition. The order of the occurrence of post-mortem rigidity has been observed differently by many observers, so that a regular order can not be enunciated. In the majority of my cases the change took place in the muscles of the face first. This is about the only place on which the majority of the authors will agree, and even the laity know well the characteristic changes in the eyelids and jaw. In my series of cases, rigidity, soon after attacking the face, invaded the muscles of the lower extremities, the muscles of the trunk and upper extremities, in my observations stiffening last. The period of post-mortem rigidity, as regards its duration is variable, certainly enduring longer in winter than in summer. In my series of cases I have seen it last in one case two weeks, in another for three weeks. It was a common occurrence to find rigidity in the cases of still-born children and even in children who had breathed a few times, to occur very rapidly. Of the number of drowned included in my observations, 95 per cent. showed marked and lasting rigor mortis; this is due to the fact that the water is always a few degrees colder than the air, and also that it is a better conductor of heat, in this manner the process of decomposition is retarded, but this rule does not hold good in all cases, for it has been shown that decomposition may, and does occur even in a warm bath, in hot countries, and when the temperature of the dead body is above the normal. The appearance of rigor mortis and its duration are due in great part to the development of the muscle and its nutrition, the nutrition being altered by the amount of suffering or fatigue the person was subjected to before death. In all the cases where paralysis had existed before death, the paralyzed limbs were also attacked with the rigor mortis, which is such a constant sign of death that some authors claim that it is never absent in any case. In some diseases where the temperature is very high, and death comes uninterruptedly till the muscular tissues have begun to alter under the effects of putrefaction. Rigor mortis occurs sometimes a little before the disappearance of muscular softening, but usually it denotes the end of muscular flaccidity. The

body is now as rigid as a bar of iron and all efforts avail nothing to bring it into a state of contraction. Whatever position the limbs were in, when rigor mortis begins, that position they retain, and it takes considerable force to move the limbs. This condition exists until putrefaction begins, but the length of time of its duration is variable: it affects all the muscles externally and internally; when rigor mortis is once on the wane, and disappears entirely, it never returns. When it does disappear it is followed by the first processes of putrefaction, although decomposition may occur in some organs while the body is yet rigid. In cases where severe and prolonged convulsive movements from whatever cause precede death, rigidity sets in early. Not only does it occur early, but it disappears very rapidly, in those who die from exhausting affections, of whatever nature. It may last for days, while it usually exists about thirty hours. The duration of rigor mortis is modified by temperature, by the physical condition of the person before death and by the mode of death. In this connection I may state that the age of the subject has an influence on its duration. Of the 7900 dead bodies of human beings observed by me, 3602 were in the stage of cadaveric rigidity, at the time of inspection. In those which were inspected, in cool or cold weather the cadaveric stiffness of the limbs was most marked and continued longer than in those bodies exposed to heat of any high degree, as was also the case in the bodies of subjects who had died suddenly or quite so, while in apparent good health. In cases of death from suicide, homicide, or accident, the duration of this condition of cadaveric rigidity was also of greater length than in the instances of persons dying of the every-day affections. Of course these observations refer particularly to the bodies of those of tender age, whether infantile or senile. There is no doubt of the fact that the volume of the muscle which becomes rigid, and they certainly do all become so, is diminished in its calibre. They are no longer in a condition of irritability, or elasticity; their mobile condition, under the influence of the experimenter's fingers, is displaced by a condition akin to an immobile body of whatever nature. They become firm in their consistency; their flaccid condition is a phenomenon of the past. How often is it seen that a body is found dead in bed, in a position very like the position taken on retiring to sleep; the supposed live person

is not disturbed. On further investigation, it is found that the person is really dead, and the life-like position is due to the fact that the muscles retain the exact position they assumed immediately before death, or occupied at the time rigidity came on. Cadaveric rigidity is a condition that is common to all the muscles, voluntary or involuntary. It is a phenomenon which is dependent on the state of the muscle itself, since it is found in these structures no matter what the condition of the surrounding tissues is. While the influence of a cool temperature delays the appearance of rigor mortis it also retards its disappearance. In 17 cases I have seen rigor mortis complete within two hours; in 140 cases it was complete in three and a half hours; in 162 cases it was complete in five hours; in 206 cases it was complete in five and a half hours; in 292 cases it was complete in six hours; in 1798 cases it was complete in seven and a half hours, and in the balance of the cases it showed itself as complete in from eight to fifteen hours, that is in 986 cases.

As before stated, rigor mortis may not appear for many hours. This is regulated by the suddenness of the death, or by the previously weakened condition of the body. A firmly contracted heart may be mistaken for a hypertrophy of that organ; whereas it is but an indication of the well-known fact that voluntary muscles stiffen later than the involuntary: the heart being an involuntary muscle, becomes hard and contracted as a result of the processes of post-mortem rigidity almost as soon as death occurs. But there are other muscles which take on this early rigidity, for instance the muscles which compose the eyelid, which in some cases are rigid before death occurs. Changes in the muscles of the face are very frequent before death, and when these changes do occur, it is usually the case that post-mortem rigidity fixes this change, as it were, and renders identification of the face of the body almost impossible. Warmth does not, in all cases, retard rigidity. The body is certainly not cold in all its parts before death, still rigidity will and does set in, even before the heart has ceased to beat. I have seen rigidity set in almost within five minutes of death, before and after. We sults therefrom during the height of the fever, rigor mortis makes its appearance very early and lasts a long time. I have noticed this in two cases of septicemia recently. But it has always been evident that it is not so much the disease which in-

fluences the early occurrence and duration of rigor mortis, as it is the powerful and healthy condition of the muscles. The explanation thus far given by authors for the occurrence of rigor mortis, have not been wholly accepted by the students of medico-legal-science, still the plausible theory is the one which claims coagulation of a proteid in the muscle plasma, forming a substance called myosin, as the direct cause of this peculiar condition of the muscles. Stimulation of the muscular system, by whatever means, may be accomplished before the occurrence of rigor mortis, but once this condition sets in, there is then no such thing as contracting a muscle by electric or other stimuli. In every case that I have met with, numbering 3602, this condition of rigor mortis was a sure and positive forerunner of the interesting processes of decomposition. To come back for a moment to the cause or causes of *post-mortem* rigidity, allow me to say that physiologists make the statement that the acids of the body which can no longer be removed from the body after death has occurred, coagulate the myosin, which is in the muscles: in this change the muscles become opaque instead of transparent: putrefaction develops ammonia, this ammonia, or product of decomposition, dissolves the myosin of the muscles, and thus the muscles return to a softened condition. I have noted in many cases that if the muscles were subjected to a great degree of irritability during life just preceding or at the time of death, that then the stiffness of the muscles comes on late and lasts a long period of time. In these cases certainly putrefaction shows itself late, consequently it becomes a very slow process. Rigor mortis is an incontrovertible sign of death, but occurs so late as to become like putrefaction, we might say, but a stamp to the preceding signs of death. Putrefaction is the trade-mark of real death, and, with rigor mortis, is a constant occurrence. It is claimed that rigor mortis does not occur in still-born children. I have seen it very recently in the bodies of still-born children. Rigidity may exist in the uterus, and pass away before the fetus is expelled. To fix the time when death occurred by calculation, with rigor mortis as a factor, is impossible; all that can be adduced is that death had recently taken place. To sum up, in individuals exhausted by disease, rigor mortis appears early and does not last very long, but in those dying while in apparent good health it

shows late and is of longer duration. Rigor mortis is undoubtedly the first change ushering in putrefaction, the chemic change going on in the muscles during or just preceding rigor mortis being the first step in this process. Rigor mortis is an almost constant sign of death.

9. PUTREFACTION.—Putrefaction is a process full of ingenious changes and phenomena. Chemic phenomena taking place just before, during the moment of, and after death, result in changes in organs of the dead body, whether those organs have been in a condition of pathologic alteration or not. It distributes its products through channels, numberless to conceive, to all parts of the body, setting up in one a condition akin to an ante-mortem pathologic feature; in another it removes, or adds to the appearance of disease.

Putrefaction affects the body in numberless ways, but chiefly through the intestinal or alimentary canal. Swarms of organisms penetrate the tissues through this tract, multiply in them, liquefy them, destroy them, thus producing such alterations, such varied changes, that at times it is very difficult to differentiate the ante-mortem from the post-mortem condition. These phenomena vary, according to the condition of the alimentary tract, whether it contained food or not. Soon after death there is a reddish froth discerned escaping from the mouth and nose. This is preceded or accompanied by changes in the eyes, and other superficial parts of the body, as previously treated of in other parts of this essay. Then faint greenish or bluish-green spots appear on the abdomen or over the groin—they may be brown or black—thus the color of these phenomena of decomposition vary. In some cases I noted the first discoloration to be on the side or sides of the nose. The odor of death, so-called, is not a constant sign of putrefaction; it may occur before death, in other cases it is absent. The discolorations noted usually occur in from one to five days, but more often than otherwise on the third day. They are accompanied by greenish patches on other parts of the body, and in the case of those on the abdomen are caused by the evolution of gases produced by the decomposition of the internal organs. The liquids forced through the mouth and nostrils are also a result of this rapid decomposition of the internal organs, which press on the walls of the stomach and intestines, becoming themselves displaced, and

displacing their neighboring organs in like manner. In several days the entire surface of the body becomes discolored, the products of decomposition—namely, the gases and liquefied products, forcing and distending the abdominal surfaces in all directions and in this manner separating the epidermis, so that it can be almost rubbed off the surface. The features become swollen as do all other parts of the body, the hair falls out, the finger and toe nails separate from their attachments, and following this there is a disintegration of all the tissues of the body. The presence of air, the existence of moisture in that air, and the high temperature of the surrounding media hasten the successive changes incident to decomposition. Age, disease and the presence of fat in the body also hasten the process. Disease, bad habits, death from some poisonous gases also favor its rapid onset, while other poisons, drowning and quick burial retard its advent. Changes may be noted in the body showing it has begun in a few hours after death: to follow the changes in the different organs is an impossible procedure, suffice it to say that the very first sign of putrefaction is a sufficient and certain test of death; while all other phenomena may be counterfeited, that of decomposition can not. It is a certain but a variable process, as is evidenced by the fact that the rays of the sun may effect more and rapid changes than two weeks' burial in the earth. The brain and eye decompose rapidly, because they contain a large amount of moisture; the hair, bones and nails not so, because they contain little or no moisture. The muscles become pulpy, and form an almost fluid mass of putrefactive tissue. In 268 cases of putrefied bodies observed by me I found that the trachea becomes affected first, the uterus in the majority of instances decomposing last. Putrefaction as it affects the tissues of the body is a spontaneous change; this change is a common one and attacks the tissues successively, resolving them into new and similar products. As an almost absolute rule it begins as rigor mortis ceases, although they may occur together. In order for putrefaction to be taken as a sign of death it must be advanced and at the same time must be general in its appearance. Gangrene of the lungs, gangrene from local injuries and gangrene of the skin around ulcers must not be confounded with the decomposition following rigor mortis. The gases developed from these forms of decompo-

sition differ in their constituent parts from the gases formed as a result of death of the body as a whole. Coincident with the formation of putrefactive gases, there is a softening and discoloration of all the organs of the body, although the process of decomposition may attack different organs in an entirely altered degree. The structure of the organ, the quantity of blood contained in the organ, and the ease with which it can be reached by air, all have an influence, while discoloration of an organ after death may, and does, occur in parts, softening of that organ attacks it in entirety. Putrefaction changes the entire mass of animal or organic matter, of which the body is composed, into a mass of inorganic matter. Whilst this change, or transition, is going on gases are necessarily given off; these produce the changes in the color of the surface of the body and also of the internal organs. By the action of these gases on the fluid blood, which has by this time been forced to the surface, whatever may be the mode of the destruction of the body in these processes of putrefaction, it is a certainty that fermentation of the tissues is a prominent factor, producing gases, which in some manner return the body to the mineral kingdom, from which, if we are to set our faith in revelation, we exist, through the hands of an all-wise Creator, who formed man from a product of the mineral kingdom, clay. Putrefaction is the surest, perhaps the only infallible sign of death, absolute and undeniable. The signs are innumerable; they may vary—some of them are found in the living body, some have failed of substantiation, but putrefaction never failed and never will. It is conclusive, it is reliable. To avoid the necessity of waiting for this process to take place, it would prevent all possibility if the radial or temporal arteries were opened with the ever-present scalpel, and left open for an hour. Decomposition does not manifest itself early enough to be made a necessary legal test, in case the authorities should select it as the one to be made, to secure the permit of burial. For certainly, if it were made the legal test, we would be obliged to wait until the tissues of the body began to undergo dissolution and there appeared a discharge from the mouth, nose and eyes.

Leaving out of consideration the cutting of the radial, or temporal artery, there does not seem to be any determinative principle of the question of real or apparent death, excepting the fact of

putrefaction. The old-time vulgar method of approaching a lighted candle or a well-polished mirror to the nose of the person supposed to be dead is still greatly relied on as a good means of judging after the pulse has ceased to be perceptible and the heaving motion of the chest has stopped. The complete immobility of the body, the absence of respiration, the disappearance of cardiac pulsation, the fixedness and sinking of the eyes, the dilatation of the pupils, are not and never will be in themselves conclusive evidence of death; but signs of decomposition following cadaveric rigidity can only be considered as conclusive proof of the cessation of life. The point of my paper will be reached, if I have proved that the results of the several tests mentioned throughout the paper are satisfactory as following and corroborating each other; but in nowise would I claim that they are adequate. Science has certainly supplied us with signs of death, sufficient in number, when taken together, to brand him who does not know enough about them to guard against the possibility of burial alive as ignorant and culpable.

My conclusions, then, are *that as a certain sign of death, we have putrefaction, which in itself may be taken as a test; but the most certain test to be applied, without possibility of error, I hold to be the prompt and immediate opening of the radial or temporal artery.*

A MANUAL OF LEGAL MEDICINE

FOR THE USE OF
PRACTITIONERS AND STUDENTS OF
MEDICINE AND LAW.

BY
JUSTIN HEROLD, A. M., M. D.,

Formerly Coroner's Physician of New York City and County; Late House
Physician and Surgeon of St. Vincent's Hospital, New York City;
Member of the New York County Medical Association, County
Medical Society, Medico-Legal Society, Society of Medical
Jurisprudence, New York Academy of Medicine, and
German Medical Society of the City of New York.

Large Octavo, 678 Pages. Illustrated. Cloth, \$4.00 Net.

PRESS NOTICES.

New York Medical Journal.

"The author has produced a practical work based on American jurisprudence, and it is likely to find favor with both lawyers and physicians."

Pacific Medical and Surgical Record.

"Each article in the work is so well written, so complete in itself, as almost to defy comparison. No physician can help being benefited by a careful study of this complete exposition of medico-legal science, for viewed from the stand-point of the author, it is a science, and complicated at that. The stories of individual cases, and their careful unravelling, will create intense interest in any reader, and wonder at the patient, educated brain labor involved in their elucidation."

New York Medical Legal Journal.

"It will be a valuable work to every physician, and while it does not attempt to treat many of the questions from the legal side, will be found full of interest and value to medico-legal jurists whether of law, medicine or chemistry."

FOR SALE BY ALL BOOKSELLERS.

J. B. LIPPINCOTT COMPANY, Publishers,
PHILADELPHIA.